THE YALE JOURNAL OF BIOLOGY AND MEDICINE 65 (1992), 223-241

The Discovery of the Body: Human Dissection and Its Cultural Contexts in Ancient Greece

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Received May 10, 1991

In the first half of the third century B.C., two Greeks, Herophilus of Chalcedon and his younger contemporary Erasistratus of Ceos, became the first and last ancient scientists to perform systematic dissections of *human* cadavers. In all probability, they also conducted vivisections of condemned criminals. Their anatomical and physiological discoveries were extraordinary. The uniqueness of these events presents an intriguing historical puzzle. Animals had been dissected by Aristotle in the preceding century (and partly dissected by other Greeks in earlier centuries), and, later, Galen (second century A.D.) and others again systematically dissected numerous animals. But no ancient scientists ever seem to have resumed systematic *human* dissection. This paper explores, first, the cultural factors—including traditional Greek attitudes to the corpse and to the skin, also as manifested in Greek sacred laws—that may have prevented systematic human dissection during almost all of Greek antiquity, from the Pre-Socratic philosopher-scientists of the sixth and fifth centuries B.C. to distinguished Greek physicians of the later Roman Empire. Second, the exceptional constellation of cultural, political, and social circumstances in early Alexandria that might have emboldened Herophilus to overcome the pressures of cultural traditions and to initiate systematic human dissection, is analyzed. Finally, the paper explores possible reasons for the mysteriously abrupt disappearance of systematic human dissection from Greek science after the death of Erasistratus and Herophilus.

I

One of the more stunning moments in the history of science [1] was the revolutionary introduction of systematic human dissection and, in all probability, of systematic vivisectory experimentation on condemned criminals [2] by the physician Herophilus of Chalcedon [3], a contemporary of Euclid, in Alexandria [4] in the early third century B.C. These new methods of research were used for a mere generation or so before being abandoned—Herophilus' younger contemporary, Erasistratus, being the only other ancient scientist to whom they are attributed.

This remarkable event presents a rich complex of puzzles. For one thing, this period was not only the *first* but also the *last* time, in the roughly thousand years of ancient Greek science, that human cadavers were systematically dissected. Indeed, not until the fourteenth century was systematic human dissection resumed. Animals had, of course, been dissected by Aristotle in the fourth century B.C., but never humans. In what social, cultural, and political contexts was it possible for an ancient Greek to open human cadavers? For what purposes? With what justification? Provoking what responses? What had rendered the practice impossible for so long? What rendered it impossible again for more than 15 centuries after Herophilus and

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Erasistratus? And what do these considerations suggest about the importance of the larger contexts within which science is practiced?

By exploring, in particular, some traditional Greek ideas about, and valorizations of, the corpse, the skin, and cutting, one might begin to approach an understanding *(a)* of the cultural heritage that prevented human dissection during almost all of antiquity, and, consequently, *(b)* of the radical audacity of the human hand that first cut open cadavers for heuristic, scientific purposes. In part II of this contribution, elements of cultural constraint are explored; in part III, factors that might have emboldened Herophilus and Erasistratus to violate and overcome the constraining pressures of tradition are discussed; part IV offers some reflections on the abrupt discontinuation of systematic human dissection after Erasistratus and Herophilus.

Before proceeding to these major questions, however, I offer a brief glimpse of why—apart from the element of innovative, daring defiance of tradition—the short-lived ancient dissection of humans by Herophilus and Erasistratus can legitimately be called a "stunning moment in the history of science."

Any summary of the extensive anatomical and physiological discoveries made by Herophilus and Erasistratus through human dissection and vivisection might run the risk of being a caricature. A few examples nevertheless will illustrate the extent to which they contributed to the discovery of the human body. By dissecting human cadavers, Herophilus succeeded in distinguishing between the ventricles of the brain and recognizing the physiological significance of the fourth ventricle [5]. Without any of the major instruments of modern medical technology, he discovered the nerves, provided a description of at least seven pairs of cranial nerves, and distinguished between sensory and motor nerves [6]. He meticulously differentiated between at least four coats or membranes of the eye, bestowing upon subsequent anatomical terminology the terms "cornea" (a Latin translation of Herophilus' term *kerato-eidēs*), "retina" (a Latin translation of Herophilus' term *diktyo-eidēs*), and "choroid coat" [7]. Furthermore, he discovered the heart valves, and his younger contemporary Erasistratus experimentally illustrated, it seems, their function by demonstrating the irreversibility of the flow through the valves [8]. Erasistratus also offered an admirable account of the bicameral heart as a mechanical pump or bellows and, like Herophilus, he gave a detailed account of the vascular system based on a systematic anatomical and functional distinction between veins (*phlebes*) and arteries (*artēriai*) [9].

Moreover, Herophilus provides the first accurate description of the human liver, the first investigation of the pancreas, and a descriptive and functional anatomy of the male and female reproductive parts that was not improved upon for centuries [10]. Herophilus also demystified the human womb by recognizing that it is not bicameral, by abandoning the Hippocratic notion that the womb wanders and thus causes hysterical suffocation, and by discovering the ovaries, the broad ligaments, and the tubes [11].

Like practically all science, the science of Herophilus and Erasistratus is of course a combination of insight and blindness, of uncovering and covering, of unwittingly supplementing and suppressing, of augmentation and elision, in the slippery process of turning observation, hypothesis, and experiment into text. But this selective enumeration of their discoveries offers a brief illustration of the remarkable, though brief, explosion of knowledge of the human body entailed by the first, and only, years of *systematic* human dissection in antiquity and, indeed, before the Renaissance.

In order to understand and evaluate the extraordinary historical "aberration" represented by Herophilus' and Erasistratus' human dissections, it is useful to ask what it might have meant, culturally and morally, for a Greek of the third century B.C., to cut through the human skin and deeply into the human body for purposes of scientific exploration. What cultural reverberations might have echoed through the mental and psychic recesses of a Greek philosopher-scientist contemplating or performing such an act, and through the minds of those who learnt about it?

II

It often is said, quite vaguely, that religious, moral, and esthetic taboos, as well as their psychological concomitants, inhibited practically all ancient and medieval physicians from opening the human body for anatomical purposes. Indeed, before Herophilus and Erasistratus, relatively superficial surgical incisions and excisions prompted by pathological conditions constituted the usual limit of "cutting" human bodies, although there are a few notable exceptions. (In *later* antiquity, I hasten to add, more invasive surgical procedures were introduced, including suture of the large intestine, cutting of bladder stones, and Galen's famous, successful surgical exposure of the heart in the second century A.D. [12]. But even then, cutting open a *deceased* human being once again simply lay beyond any culturally accepted limit.) It is readily conceded that human corpses were at times tampered with, also before the third century B.C., but such acts tended to be dealt with as punishable desecrations and as violations of culturally acceptable boundaries [13]. The perpetrators were considered polluted and polluting, a source of danger to individual and community alike.

More specific sociocultural features of the "taboo" against human dissection become visible, as suggested, through an exploration of Greek beliefs and practices pertaining to the corpse, the skin, and "cutting." (It perhaps goes without saying that it lies in the nature both of the questions addressed here and of the available ancient evidence that the observations and suggestions which follow are, to some degree, speculative; they are intended chiefly to stimulate discussion rather than to offer dogmatic conclusions no longer open to questioning.)

First, what was the corpse to the majority of Greeks? Substantial evidence is provided most notably by ancient Greek inscriptions that record sacred laws. Hundreds of these sacred laws survive (though often partly mutilated), carved into stone and marble at ancient sanctuaries [14]. Unlike other ancient texts, these sacred inscriptions have not been subjected to the vagaries of manuscript transmission: the ancient stones in which they are inscribed survive, and reading them hence yields an unusual sense of immediacy, of unfiltered confrontation with rules, beliefs, and practices that regulated ancient communities, also with reference to cadavers.

In many ancient Greek sacred laws, every human corpse is considered a significant source of pollution for all who, in any fashion whatsoever, come into contact with it or stand in a relation of kinship to it. An especially common expression of the belief that corpses entail religious and civic pollution is the prohibition against the following activities on the terrain of a sanctuary or in a temple: dying, abandoning or burying a corpse, giving birth, having sexual intercourse, urinating, defecating, and, in the Hellenistic period, menstruating [15].

It might at first glance seem paradoxical, as Robert Parker has observed, "that the most intimately natural of all experiences"—death, birth, sexual intercourse, urinating, defecating—"should also be seen by people living close to nature as potent

sources of impurity and danger" [16]. But such ideas in fact recur cross-culturally. Furthermore, in ancient Greece not only the sacred laws, which bind all inhabitants of a locality and thus construct and express the ideological solidarity of a community, but also historiography, poetry, and, to some extent, philosophy resonate with the pervasive sense of the perilous impurity of the corpse, whose polluting power could touch even divinities.

The most famous instance in poetry is the conflict between Antigone and Creon in Sophocles' *Antigone* over Polynices' corpse, but even better known in antiquity was the irreconcilability of corpse pollution with the sacredness of Delos. Greek writers as diverse as the fifth-century B.C. historian Thucydides, the first-century B.C. geographer Strabo, and the Alexandrian poet-scholar Callimachus [17] (who was Herophilus' contemporary, and who alludes to Herophilus' obstetrical theories in one of his poems [18]) confirm that the island of Delos, by virtue of being sacred, had to be kept free of all taint of the processes of mortality; neither death nor burial was permitted anywhere on Delos. Another contemporary of Herophilus, the philosopher Teles, contrasts Greek and Egyptian attitudes to corpses, saying: "We [Greeks] shrink both from looking at and from touching corpses" [19]. The comic poet Philemon is said to have dreamt the night before he died that nine young women were departing from his house. When he asked them why they were leaving him behind, they responded that it was contrary to sacred law ("not *themiton*") for them to remain and for him to listen to them; they were, Aelian assures us, the nine Muses in fear of corpse-pollution [20].

A particularly pertinent fact, to my knowledge never noted before in the context of Erasistratus' scientific activities, is that we happen to be exceptionally well informed about the attitudes to corpses in Erasistratus' native city, Iulis, on the Aegean island Ceos. On two sides of a fifth-century B.C. stele from Iulis a generous total of 51 lines record a detailed sacred law concerning the disposal of corpses [21]. As Robert Parker has pointed out, this law displays many resonances with Solon's late seventh- or early sixth-century B.C. funerary legislation for Athens and with other Greek sacred laws, and it therefore stands neither isolated nor unique [22]. The law from Iulis and numerous related Greek sacred laws offer the following kinds of details concerning Greek attitudes to corpses, as Parker and others have recognized.

A house in which there is a corpse becomes polluted at the very moment of death. A special water vessel, set outside for the use of kinsmen leaving or entering the house, visibly warns those who do not wish to incur pollution not to enter the house at all. The water is brought from elsewhere, since the water supply of the house, like its fire, is instantly polluted by the presence of a corpse. The women of the household wash, anoint, and crown the corpse, dress it in white robes, and lay it on a bier strewn with purificatory olive branches and olive leaves. In a typical manifestation of what some anthropologists have called the "ambiguity of the sacred," the corpse thus is made symbolically pure, even while still contaminating all people and things around it. Of all present, the corpse—the pollutant—now alone wears the crown, emblem of purity. Early on the third day, before dawn, to protect passersby from pollution, the body is carried outside the city limits, away from and beyond the civic body which it endangers, and away from all temples—with, of course, no priest in attendance, since the corpse would pollute this symbol of purity. The contrast of this "ideology of the corpse" with that displayed in modern Western burial practices, which often have

church or synagogue and priest, minister, or rabbi at their center, could hardly be greater.

The burial of the corpse is a new turning point, and it is followed by the purification of persons and things contaminated or polluted by the corpse. The mourners now wash and bathe, and the house is sprinkled with sea water early the next morning. A fresh fire is started on the hearth, and only now, for the first time since the living body turned into a polluting corpse, may limited contact with the gods be resumed through offerings at the hearth.

Yet so powerful is the pollution caused by the corpse, in Iulis as elsewhere in Greece, that even now the purified mourners are not truly pure. Even now, for those polluted by the corpse, the laws prescribe further periods of exclusion from all shrines, i.e., from the vital centers and sources of community, for periods ranging from two to 41 days, depending on how intimate the polluted person's contact with the corpse has been [23]. Moreover, the corpse, even when duly and properly interred, remains a source of pollution or *miasma* for a long time. At progressively increasing intervals of time, further purificatory rites therefore have to be performed at the tomb. As though that were not enough, each such tomb ritual once again pollutes the participants, requiring their renewed purification and their renewed exclusion from shrines, sometimes for three days [24].

From the island of Cos, where Herophilus may have studied with his famous mentor Praxagoras before going to Alexandria, we have similar laws that illustrate the polluting power attributed to corpses. Furthermore, an inscription on a marble stele in Cos, carved during the lifetime of Herophilus but never before noted by historians of science, strikingly calls for purification of the community whenever any human bone, *osteon anthropou,* is found in a public space [25]. And at Athens, where Erasistratus may have studied in Aristotle's school, anyone who neglected to bury an untended corpse immediately was subjected to the dreaded "Bouzygean curses" [26]. The only exceptions were symbolic rejections, away from human habitation and beyond the city boundaries, of malefactors harmful to the public good, such as traitors and temple-robbers [27].

These extensive details provide a vivid sense of the massive power of pollution and exclusion in the Greek corpse tradition, also in Erasistratus' home town. There might have been sound, at times transparent, hygienic reasons for such sacred laws, as there often are, but these examples show that the power of the corpse as a source of individual and collective pollution is not only an effective fictional or dramatic device; rather, it is a palpably present, regular feature of daily life in ancient Greece, also at the time of, and in the spaces of, Herophilus and Erasistratus.

A further element of cultural context is worth exploring: the cultural valorizations of the skin. What did Greeks think of when they were confronted with skin, and especially with the possibility of cutting through human skin? With few exceptions, complex religious, social, and political Greek traditions assert the inviolability of the skin, dead or alive, human or animal, except as a means of gaining control of a crisis. The crisis that permits the exception could be collective or individual, civic or religious, moral or physical.

Among the complex features of the ancient valorization of skin as something fraught with liminal complexity and danger, several are noteworthy for present purposes.

First, skin is a magical symbol of wholeness and oneness, of the integrity of

individual or collective organisms that might become susceptible to disintegration or fragmentation. One of the reasons why these skin associations became so strong is that they operated at mutually reinforcing individual and communal levels. In a number of cults and in foundation myths, for example, a sacred skin serves as a visible symbol of the invisible "skin" that envelops and protects the community. It is a manifest sign of that which gives the community unity and cohesion, of that which expresses the solidarity of its members, and of that which ensures that the collectivity will function as a social entity in which all parts have their stable, proper place, as do parts inside the skin of a healthy individual body.

It is significant that, with a few notable exceptions, the skin is the only part of the sacrificial victim that is neither burnt as a gift to the gods nor eaten by the human participants in the sacrifice. After sacrifice, the skin remains behind, either on display in a temple or other public space, or in the hands of a priest, and it symbolically represents the soundness, integrity, and completion of the sacrificial purification from violence by violence. Many Greek sacred laws accordingly regulate the disposition of skins in considerable detail [28].

The legendary "skin of Epimenides" might also belong in this context, inasmuch as his skin symbolizes the integrity and inviolability of something sacred bestowed upon humans by divine agency. In this case, the inviolable wholeness of the skin acquires a further dimension: the skin as text (on which see also below). According to ancient sources, an oracle ordered the Spartans always to preserve the corpse of Epimenides, the shamanistic Cretan purifier, prophet, and miracle-worker. After his death, his skin was discovered to be tattooed with *grammata* (letters). These "letters" are perhaps, as Jesper Svenbro has suggested, sacred, "unspeakable" hexameters, or perhaps Epimenides' hexametric oracles. This hypothesis is rendered plausible by Greek proverbial traditions, according to which "skin of Epimenides" refers to *apotheta,* i.e., to "things stored up" or "things laid by," including especially "things stored up secretly," such as "mysteries" or "secrets" for special occasions. Epimenides' inscribed skin thus remains behind in perpetuity to ensure the integrity of his verbal magic beyond the rupture of death; his skin efficaciously represents the order implicit in his sacred oracles; his dead skin, preserved *whole,* becomes his eternally sound, unfragmented, immortal text [29].

A number of myths also associate the founding of a city with a sacred or symbolic "collective" skin of the new community: a skin which signifies the integrity, oneness, and inviolability of the new city. Thus Cecrops, one of the legendary founders of Athens, is closely associated with the sacred hide of an ox—probably a sacrificial victim—that represented the communal skin of Athens [30]. Perhaps the most famous Greek foundation myth in which skin plays a crucial role is that of the founding of Carthage ("Byrsa") in North Africa. There, a ruse of Dido's ensured that the hide of a sacrificial ox was transformed into the circumference adequate to a city, ensuring the viability, the prosperity, and, especially, the cohesion of the new community [31].

It is in part these notions of skin as the source or guarantor of spatial and temporal unity, of solidarity, of cohesion, of integrity, and of completion that express or entail the inviolability of both individual and communal skin.

Skin is also widely regarded as an external symbol of order and orderliness [32]. The skin is seen as an inviolable, natural map: as a surface on which the order or disorder of the organism it encloses can be deciphered and read. It is the exterior

sign-system of the interior, the external surface on which both internal physical disorder and internal moral pollution become physically manifest. Thus skin diseases were often seen as manifestations of moral or religious pollutions that could be washed away through purification [33]. The people of Delos are said once to have incurred a leprous disease when they allowed the burial of the corpse of a distinguished person on their sacred island [34]. There are many refractions of these beliefs in poetry, too. In Aeschylus' *Oresteia,* for example, the pollution that threatens Orestes, should he fail to avenge his father, would become visible in the form of a horrendous eruption of his skin [35].

As the text or map of the body, too—as a nature-given, decodable representation of its hidden interior—skin thus claimed a privileged, inviolable status. To violate it forcibly, except to gain control of a crisis, was to interfere with the surface version both of the physical and of the moral condition of a person.

The special cultural significance of skin becomes visible not only in the contexts of foundation myths, of sacrifice, and of sacred immortal texts, but also in the magic-filled relations between human and animal. So closely is Heracles, the exceptional *tamer* of animals, associated with exceptionally "*wild*" animal skin—the lion's skin—that he is iconographically recognizable by it. Yet, in order to become divine, he must not only shed his lion skin but also lose his own, human skin through a terrible skin agony, significantly in the context of sacrifice and self-sacrifice. To perform a sacrifice, he dons a sacrificial robe which, however, has been smeared by Deianira with a supposed love potion that turns out to be a monstrous poison. His skin is set on fire by the poisoned robe and, tearing off the robe, he painfully tears off his own skin along with it—and, with his skin, all of the legendary, magical power that had been symbolized by his lion skin. To be without skin entails not only being without power but also being without identity, and all that is left for Heracles to do is to mount a funeral pyre and to become destroyed, yet apotheosized, by fire. In the later tradition of Greek proverbs, Heracles' name significantly became associated with frightful skin diseases, including leprosy [36].

The myth of Meleager and the Calydonian boar offers a further example of human exploitation of the magic of animal skin. Meleager, for example, freely shares the meat of the mighty boar with his companions but carefully guards the magical, sacred power of its hide for himself [37]. Such examples from myth confirm what the sacred laws show in detail: that a special status and special powers were conferred on skin in a variety of ancient cultural contexts. Animal skin thus is endowed with many significant religious and magical features, and human skin all the more so.

Skin also is presented as limit and, from early to late, Greek culture displays an extraordinary sensibility in the matter of limits. In Greece, limits, on the whole, are not there to be overcome but to be accepted, not to be transgressed but to be honored, be they geographic limits, the limits represented by incurability, or the limits entailed by the fundamental fallibility of all human cognition [38]. Conversely, the transgression of limits—like crossing the liminal in many cultures—entails special dangers, both moral and physical. Transgressing the natural limit or threshold represented by another person's skin, except to resolve a crisis especially in the service of one's country, or to gain control of an individual pathological crisis, is a source of the most severe pollution [39].

Cumulatively, these and similar valorizations of skin represented part of the substantial cultural deterrent to human dissection. And it is within these cultural

contexts, too, that the extraordinary audacity of Herophilus and Erasistratus must be located and evaluated.

A third significant contextual element may be worth exploring, despite the inevitably speculative nature of the suggestions presented here. In what cultural contexts is the ancient Greek verb *temnein,* "to cut," from which the noun *anatomē*, "dissection," is derived, predominantly deployed when humans or animals are its objects? What does it mean to a Greek to hear that someone "cuts" (*temnei*) an animal or a human being? And why and when do the ancient Greeks usually do it?

It is perhaps not insignificant that the most common early use of "cut" or "cut into" is to refer to violating the skin boundary in the performance of an animal sacrifice. Its special domain is sacrifice accompanying a sacred oath, often before battle. The person performing the oath first cuts (*temnei*) strands of hair from the forehead of the sacrificial animal, divides them among those present at the sacrifice to ensure solidarity and complicity in advance of imminent sacred violence, invokes a god or gods, swears the oath, and then seals it: by slitting (*temnei*) the victim's throat [40]. At certain times and places, every domesticated animal "cut" for eating is first sacrificed in this manner, since even such cutting is polluting.

The combination of "oath" and "cutting" in these sacrificial practices presents a paradox characteristic of "the ambiguity of the sacred" to which I referred above [41]. The Greek word for oath, *horkos,* has been thought ever since antiquity to be cognate with *herkos,* "fence," "enclosure" (although its etymology remains disputed) [42]. In swearing an oath, one creates boundaries; one fences in oneself and those rendered complicitous by the oath; one binds through the efficacy of the oath's word magic [43]. By contrast, in cutting (*temnein*) the victim, one violently violates another boundary. The bloody, physical violation of the "skin fence" is rendered culturally tolerable by the magical verbal "fencing" in of the complicitous.

Also outside its sacrificial use, "to cut" tends to designate acts of violence, practically all of which, like sacrificial cutting, entail the violation of skin boundary, often in combat, as a way of trying to gain control of a crisis, be it a moral, civic, or military crisis. In these contexts "to cut" (*temnein*) often means to maim, to decapitate, or to castrate [44]. Acts of skin-transgressing cutting, in combat as in sacrifice, thus have in common, first, their violence and, second, that they belong to a context of overcoming a crisis—of coping with a threat, of resolving a critical disorder, imbalance, impurity, or impasse.

This is not to deny that there was more peaceful cutting, but when the object cut is a human or an animal, the dominant early use of *temnein* and its cognates is to refer to violent, deeply invasive acts of skin-transgression, usually prompted by a crisis [45].

A significant exception is the Hippocratic writings where, for the first time, *temnein* as skin-cutting becomes systematically domesticated and secularized. In their uses of *temnein* to refer to skin-cutting, the Hippocratics on the one hand depart from the violent mainstream tradition by using it to designate fairly conservative incisions including, especially, incisions for therapeutic blood-letting [46]. On the other hand, the Hippocratics still have in common with traditional acts of skin-cutting that they use *temnein* in order to resolve a crisis that has been triggered by impurity, danger, or imbalance, here in the body.

In expropriating *temnein* for human dissection and vivisection, Herophilus and Erasistratus, by contrast, retain the traditional context of deep, invasive cutting, while depriving *temnein* of its traditional legitimation of immediate civic or individual crisis. This new context of skin-cutting—the old mode without the old sanction—may have appeared just as unacceptable to most of Herophilus' and Erasistratus' contemporaries and successors as did the dissectors' attitude to the corpse.

I have offered only a few examples—corpse, skin, and *temnein*—of the formidable cultural traditions that may have slowed down the doctor's hand as it moved to human dissection. I hope this selective exploration of cultural contexts has evoked more concretely the enormity of the steps taken by Herophilus and Erasistratus, the exceptional nature of their methods, and the multi-layered power of the traditions they violated.

III

What were the factors that provoked and allowed Herophilus and Erasistratus to contravene these deeply entrenched beliefs and cultural habits? What prompted and permitted them to challenge the power of the religious sanctions explored above? Any monocausal explanation is likely to be inadequate. Rather, I believe that an exceptional, perhaps unique constellation of interactive circumstances prevailed in Alexandria. Space does not permit an exploration of all relevant factors, but an allusion to at least some might be helpful.

Among the pertinent factors is, paradoxically, the absence of democracy in Ptolemaic Egypt. I am aware that many have argued that the major reason why some parts of science developed in Greece in distinctive ways not found in other ancient societies is the presence of certain political structures, especially "democracy" and a "democratic" legal system, that foster dissent, debate, and critical scrutiny of arguments [47]. There might be some validity to such interpretations, but they neglect the rich evidence that, whether we like it or not, Greek science made some of its greatest discoveries and advances within non-democratic political structures such as those of the Macedonians' Ptolemaic monarchy in Alexandria. In Alexandria, a scientist's fellow-residents could not vote to ostracize or exile him on grounds of impiety, as they could—and did—in "democratic" Athens [48]; in Hellenistic Egypt, the king centrally controlled political action as well as religious life.

Furthermore, the early Ptolemies appear to have extended generous patronage not only to the famous scholar-librarians of Alexandria and to members of the Museum, but also to scientists such as Herophilus. Non-financial forms of patronage often may have been even more important to science than economic subvention. Indeed, with reference to vivisection, our ancient sources are unequivocal in their affirmation that it was the "kings" who handed over condemned criminals to Herophilus and Erasistratus for vivisectory experimentation [49]. Similar patronage, again in the form of royal intervention, may well have made scientific access to cadavers possible.

Closely related is a further factor, one that appears to have motivated royal patronage and royal intervention on behalf of scientists, viz. the ambition of the early Ptolemies to establish Alexandria as a glittering center of literary and scientific learning. Their success was remarkable, and the results included a cosmopolitan

intelligentsia committed to literary and scientific frontiersmanship [50]. Among the more celebrated scientists said to have visited Alexandria or to have resided there during the lifetimes of Herophilus and Erasistratus are Euclid, the mechanical genius Ctesibius, and the astronomer Aristarchus of Samos (known for his heliocentric theory of the universe). Several brilliant younger scientists such as Archimedes, the polymath Eratosthenes (see below), and the astronomer Conon may also have been in Alexandria toward the end of Herophilus' life. A similarly distinguished group of Greek literary critics, poets, and librarians worked in Alexandria in the first half of the third century B.C., including the poet-scholars Callimachus, Apollonius of Rhodes, and perhaps the pastoral poet Theocritus. An important point here is not only that a large number of distinguished intellectuals converged in Alexandria at this time, in part as a consequence of royal incentives, in part because any "critical mass" of distinguished intellectuals in a given location tend to attract others from elsewhere. Rather, it also is noteworthy that many of these scholars placed a premium on innovation and engaged in relatively unshackled speculation or experimentation. This is the intellectual and cultural atmosphere in which the audacious first systematic dissections of the human body became possible.

Moreover, Alexandria was a new frontier city in which traditional Greek values were not considered intrinsically superior. Indeed, the Ptolemies themselves set examples—shocking to some Alexandrian Greeks—of violating traditional Greek taboos, including the ancient Greek taboo against intra-uterine incest. The Ptolemies had their political reasons for presenting themselves as royal heirs and perpetuators of an ancient Egyptian custom—consanguineous marriage—but Greek criticism of such royal violations was quick to surface, thereby demonstrating the tenacity, also in early Alexandria, of traditional Greek taboos [51]. Significant for present purposes is, however, the fact that the Ptolemies themselves could blatantly and openly violate entrenched taboos, also concerning relations between bodies. At the very least, this is indicative of the cultural and political ambience in which scientists dared to violate taboos.

Not all factors relevant to the sudden rise of systematic dissection and vivisection were internal to third-century B.C. Alexandria. Some were antecedent or external or both. Among these is what one might call "the philosophical secularization" of the body and of the corpse.

Aristotle's success in the fourth century B.C. in developing a teleologically modeled biology as a major branch of philosophical enquiry, in part by dissecting and vivisecting various *animals,* will not have gone unnoticed in Alexandria. Nor will Aristotle's unequivocal rejection of certain traditional notions about the relation between body and soul. For example, he abandoned the Orphic-Pythagorean-Platonic idea of the transmigration and reincarnation of the soul, and instead developed a theory of soul as the more or less complex form that endows the matter of each animate organism with function and with species being [52]. The presence and influence of Aristotle's followers in Alexandria at the time of Herophilus can be documented, also in the organization of the famous Alexandrian Library [53]. None of this represents conclusive evidence that Aristotle's thought and practice *directly* provoked the Hellenistic physicians to perform human dissection, but Aristotle's zoology clearly demonstrated the value of repeated dissection, and his new version of the body represents a coherent, suggestive challenge to traditional notions of the

inviolable sanctity of body and skin. Not atypical of Aristotle's unsentimental, dispassionate statements about the human corpse and its parts are the following:

> It is clear that a corpse is a human being *in name only* [homonymously] . . . [54].
>
> Even though a dead person also has the same external form and shape, it nevertheless is not a human being. Furthermore, it is impossible that a hand rendered in whatever manner, for example in bronze or in wood, is a hand except *in name* [homonymously], just like a physician in a drawing [*or* painting]. For it will not be able to perform its own function, just as neither flutes [sculpted] in stone nor physicians in drawings can perform their own functions. Likewise none of the parts of a dead person is any longer of such a nature [as are the functioning parts, i.e., of a living person], I mean, for example, eye or hand. It is called "eye" or "hand" far too simplistically, as when a woodworker might talk of a "hand" made of wood . . . [55].
>
> So too the "hand" of a person who has died is a hand *in name only* [homonymously], just as flutes in a stone sculpture might also be called "flutes" . . . [56].

A cadaver, then, is no more a source of anxiety, mystery, or awe for Aristotle than is a piece of wood, stone, or bronze. To speak of the corpse as somehow being the "person" from whom it derives is to engage in linguistic confusion, he argues.

Perhaps as significant as Aristotle's dissections and his attempts at de-mystifying and secularizing the soul and the corpse, is the radical materialism of two schools of philosophy newly in ascendance in Athens at the time of Herophilus and Erasistratus: Stoicism and Epicureanism. Although they represent contrary traditions on most issues, the Stoics and Epicureans were in agreement that all entities, animate and inanimate, are nothing but matter (or, as the Epicureans insist, matter and "void"). Even the soul, which Aristotle had still identified as the form that is always joined to matter, now is constructed as being nothing but matter of a certain kind or in a certain state. According to both Stoics and Epicureans, neither death nor the corpse is to be feared: death is simply either a change in the state of matter or a rearrangement of matter [57].

Of particular interest in this context is the Stoic doctrine of a class of things that are morally indifferent (the *adiaphora*). To simplify dangerously, the Stoics argued that all things can be divided into three moral classes: the good, the bad, and "neither" or "indifferent." This basic division, which is elaborated through complex subdivisions, has much in common with Herophilus' taxonomy of the *ars medica,* as I have pointed out elsewhere [58]. In this light, it is significant that the Stoics explicitly assigned death and the corpse to the class of morally indifferent things [59]. Even necrophagy is said by the noble Stoics to be morally indifferent [60].

This classification completes the philosophical secularization of the corpse and the philosophical depollution of the cadaver, even as sacred laws detailing the old taboos about the corpse continue to be carved into stone, in Hellenistic Egypt as elsewhere. Mere rearranged or transformed matter, devoid of moral consequences for itself and for others—this, at the time of Herophilus and Erasistratus, was the latest philosophical version of the traditionally dreaded dead body.

Greek philosophy, Ptolemaic politics, imaginative royal patronage, the attraction exercised by Alexandria on numerous innovative intellectuals, the cultural ambience

of a frontier city, and royal violations of old Greek taboos are, however, not the only interactive factors that may have been at work in enabling Herophilus to initiate this short-lived piece of scientific daring.

Although no ancient or modern scientist or historian of repute has mistaken *religious* mummification for systematic *scientific* dissection [61], the age-old Egyptian practice of religious embalming might have been seized upon by eager scientist and ambitious king alike as a legitimating precedent. It also might have been regarded as evidence that cadavers could be opened with moral and religious impunity. Yet, if it functioned as such, this "precedent" found very limited acceptance: as pointed out above, only two Greeks—Herophilus and Erasistratus—ever practiced systematic human dissection.

The exceptional convergence of these and other interactive political, social, cultural, economic, ideological, scientific, and philosophical factors might well have facilitated the relatively brief but momentous crossing of forbidden boundaries by Herophilus and Erasistratus.

IV

Even more problematic than accounting for the spectacularly productive, systematic introduction of a previously "forbidden" heuristic and experimental tool, in violation of taboo, is explaining its apparently abrupt disappearance after the death of Herophilus and Erasistratus, not only from Alexandria but also from *all* of subsequent ancient Greek science [62], and indeed from all science until the fourteenth century. What might account for the sudden abandonment of a new method of investigation and explanation that had yielded such a quick, rich harvest? Why did other scientists not emulate the scientifically productive dissecting and vivisecting work of Herophilus and Erasistratus on humans? In particular, why did not even the many subsequent physicians who identified themselves as "Herophileans" or "Erasistrateans" continue systematic human dissection? As in parts II and III (above), the extant evidence is such that any "explanation" is bound to be hypothetical and provisional to some degree and hence open to challenge, but here, too, my purpose is to stimulate reflection on an historical puzzle, rather than to offer dogmatically assertive conclusions.

It has been suggested that the simplest explanation for the disappearance of vivisective and dissective experiments in Alexandria might be the coincident disappearance or reversal of many or all the factors discussed above (part III). In fact, however, in the generations immediately after the death of Herophilus and Erasistratus, almost all the factors introduced above continued to play a role in the life of Alexandria, while systematic human dissection was discontinued, judging by all the available evidence. Ptolemaic autocracy, the absence of democracy, royal support of the Alexandrian Museum and of the Library, a critical mass of brilliant intellectuals working in a variety of fields, and so on, continued, yet human dissection did not. Aristotelian philosophy, Stoicism, and Epicureanism did not suddenly disappear from the Greek world with the death of Herophilus and Erasistratus, as little as mummification disappeared from Egypt. Furthermore, distinguished scientists continued visiting Alexandria or practicing there in the generation after Herophilus. One therefore has to look to other factors—both traditional and novel factors—for an understanding of the apparently abrupt discontinuation of systematic human dissection and vivisection.

In this context, it should be kept in mind that not all branches of science and medicine are subject to the same cultural pressures; not all are susceptible to the same cultural, economic, or political determinants; and not all are responsive to the same opportunities. Among the tenacious traditional factors that probably came into interactive play in the case of human dissection and vivisection, but not in the case of Alexandrian mathematics or astronomy, are, for example, the religious beliefs and cultural valorizations introduced above (part II). As Hellenistic sacred laws and other Hellenistic texts richly illustrate, traditional Greek beliefs about the burial of the dead, about bloodshed and pollution, about the corpse, and about skin did not vanish with the introduction of human dissection [63]. Furthermore, as indicated above, some Alexandrian Greeks immediately dared to attack even the autocratic Ptolemies' violations of old Greek taboos [64]. The power, tenacity, and insistent reassertion of traditional values and of ancient taboos hence should not be underestimated, in trying to understand the discontinuation of systematic human dissection [65].

There are, however, also novel factors that come into play from the mid-third century B.C. on. Conspicuous among these is a new, rival school of medical thought, probably founded or co-founded by a renegade pupil of Herophilus, Philinus of Cos, in the mid-third century B.C. Its members call themselves "Empiricists" (*empeirikoi*), after their own formulation of a new epistemology and a new theory of method based almost exclusively on experience (*empeiria*), and they lump together all their motley warring opponents, such as the Herophileans and Erasistrateans, under the label "Rationalists" (*logikoi*) or "Dogmatists" (*dogmatikoi*). On methodological, epistemological, and clinical grounds, the Empiricists claim that human dissection is scientifically unnecessary [66]. Not unlike modern behaviorists, such as those inspired by B.F. Skinner, they argue that only clinical "results" or clinical efficacy matters; the invasive investigation of "hidden causes" and the construction of causal theories are unnecessary, are impossible in principle, and are clinically irrelevant. Instead, desirable clinical results can be obtained first and foremost by the "empirical" collection of non-invasive, even random observations (*peira* and *empeiria*), second by using transmitted, non-causal reports of proven remedies (*historia*), and, if no proven remedies are at hand for a given ailment, by the improvisational use of relatively simple analogies in therapeutics (*metabasis* by similarity) [67].

The Empiricists' attacks on dissection apparently went to the heart of Herophilus' and Erasistratus' justifications of systematic human dissection and of vivisection experiments, and the Empiricists also confronted the dissectors' statements of purpose head-on. According to Celsus, the first-century Latin encyclopedist who is a major source for Hellenistic medicine, the "Rationalists" justified human dissection and vivisection by claiming that both "hidden" and "evident" causes of diseases must be known, as must the "natural activities" of the internal parts, if one is to treat patients effectively. Celsus then adds:

> Moreover, since both pains and various types of diseases arise in the *internal* parts, they [scil. the "Rationalists"] think that no one who is ignorant of these parts can apply remedies to them. It therefore is *necessary* to *dissect* the bodies of the *dead* and to examine their viscera and intestines. Herophilus and Erasistratus, they say, did this in the best way by far when they *cut open* people who were *alive,* criminals out of prison, received from kings. And while breath

> still remained in these criminals, they *inspected those parts which nature previously had concealed,* also their position, color, shape, size, arrangement, hardness, softness, smoothness, connection, and the projections and depressions of each, and whether anything is inserted into another thing or receives a part of another into itself. For, they say, when pain occurs *internally,* it is impossible for one who has not learned in which part each *internal* organ or intestine lies, to know what hurts the patient. Nor can that part which is ill be treated by one who does not know what it is. And when a person's viscera are exposed by a wound, one who does not know the color of an [internal] part in its healthy state, cannot recognize which part is intact and which damaged; thus he cannot even come to the aid of the damaged parts. *External* remedies also can be applied more suitably by people acquainted with the positions, shapes, and size of the *internal* parts. . . . *Nor is it cruel, as most people maintain,* that remedies for innocent people of all times should be sought in the sacrifice of people guilty of crimes, and of only a few such people at that [68].

It is, in part, precisely these articulations of the purposes and justifications of human dissection and vivisection that are targeted by the Empiricists' polemics, as Celsus subsequently makes amply clear [69]. To their general anti-etiological and "anti-theoretical" arguments, the Empiricists add the specific points that the very act of laying open the body alters the internal parts, and that even uninjured parts often vary in appearance due to non-pathological factors such as fear or hunger or fatigue. Moreover, against dissection they argue specifically that the parts in the dead have undergone alteration and hence are so different from the parts in the living that it is useless to observe them [70].

Soon after Herophilus' death, the Empiricists became the most prominent "school" of medical thought in Alexandria. Their vehement, articulate, and nuanced objections to systematic human dissection, both on epistemological and on clinical grounds, represent a powerful new *scientific* complement to the reassertion of the more traditional *religious* and moral reservations.

A further new factor that might be relevant here is one to which I alluded above: the increasing scholarly energy expended by both Empiricists and "Rationalists" of varying persuasions (notably including many Herophileans) on the exegesis of Hippocratic treatises, on Hippocratic lexicography, and on medical doxography. Herophilus, too, had done critical work on Hippocratic texts, but it was not his central concern. Cause and effect are difficult to identify in this case, but it is noteworthy that, in the generations after Herophilus and Erasistratus, more Alexandrian physicians than ever before followed the scholarly lead of the great Alexandrian philologists and literary critics such as Zenodotus, Callimachus, Philetas, Simias, and Aristophanes of Byzantium, rather than the lead of the pioneers of systematic human dissection [71]. The physicians turned increasingly to detailed critical analyses of texts from the past and to the collection and criticism of precursors' views—activities that have their value, too—while abandoning human dissection and experimental vivisection. Treatises on physiology continued to be written, notably by Herophileans, and pharmacology was immensely popular, but no discoveries were made that match those of Herophilus and Erasistratus in range, durability, and accuracy.

Early Alexandria was a frontier city, but it also was a city without frontiers, a city without skin, as some ancient writers sensed. Plutarch, in his *Life of Alexander,* records the following episode in his description of the founding of Alexandria in 331 B.C. by Alexander the Great:

> And when he (Alexander) saw a site of outstanding natural advantages, he . . . ordered the plan of the city to be sketched out on the ground in conformity with the configuration of the site. There was no chalk ("white earth") at hand, so they took barley-flour and traced out with it on the dark soil a rounded area, to whose inner contour straight lines extended . . . so as to produce the figure of a chlamys [a military cloak]. The king was delighted with the design, but suddenly birds from the river and the lagoon, infinite in number, and of every kind and every size, swooped down on the place like clouds and did not leave behind the least particle of the barley-flour, so that even Alexander was thoroughly disturbed at the omen. However, the seers exhorted him to be confident, since, they said, the city founded here by him would have abundance of resources and would be a nourisher of human beings from every country [72].

It was to this city without a boundary, robbed of its skin at its very founding, and hence open to all, that Herophilus came from the remote Bosporus. And it was in this frontierless city that he became the first to cross the last frontier. It was here that, to the dismay of later Greeks, pagan and Christian alike, he delved more deeply than any precursor into what nature had concealed; it was here that he made the discoveries with which I started these reflections. Perhaps only in a skinless city could Herophilus have cut so deeply beyond the human skin, living and dead. Yet in a skinless city, too, as the preceding reflections suggest, science is not insusceptible both to the spur and to the bit of those paradoxical human intricacies which we call culture.

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1. *Versions of parts of this paper were presented at The New York Academy of Sciences, at the University of Texas in Dallas, at Amarillo College, and to the Oriental Club at Yale University. I am grateful to participants on these occasions for helpful suggestions, notably to Drs. Vivian Nutton and Philip Periman, and to Professors Carol Nicklaus, Nancy Siraisi, Bruce Chandler, Timothy Weiskel, Stanley Weinstein, Dimitri Gutas, and Gary Beckman. Dr. Jesper Svenbro and Mr. Zlatko Pleše also offered valuable suggestions.*
2. *See* von Staden H: Herophilus. The Art of Medicine in Early Alexandria, fragments 63a–74. Cambridge, UK, Cambridge University Press, 1989, pp 187–194
3. *For the life and date of Herophilus, see* ibid, pp 35–66
4. *On the founding of Alexandria by Alexander the Great in 331 B.C., i.e., only a few decades before Herophilus arrived there from Chalcedon, an obscure town on the Asiatic side of the Bosporus, see* Arrian: Anabasis of Alexander 3.1.1–3.2.2; Plutarch: Life of Alexander 26; Diodorus of Sicily: Bibliotheca historica 17.52; Quintus Curtius: Historiae 4.8.1–6; Strabo: Geography 17.1.6 (792C); Ammianus Marcellinus: Res Gestae 22.16.7
5. [2], fragments 77a–78, pp 196–199
6. Ibid, fragments 80–86, pp 200–205; *see also* [61]
7. Ibid, fragments 86–89, pp 203–206
8. *See* Garofalo I: Erasistrati fragmenta 201–202. Biblioteca di Studi Antichi 62. Pisa, Italy, Giardini Editori, 1988, pp 133–134, 23–26; von Staden H: Experiment and experience in Hellenistic medicine. Bulletin of the Institute of Classical Studies 22:178–199, *especially* 182–184, 1975
9. *Cf.* Harris CRS: The Heart and the Vascular System in Ancient Greek Medicine. Oxford, UK, Oxford University Press, 1973, pp 211–213; von Staden H: Cardiovascular puzzles in Erasistratus and

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10. [2], fragments 60a–b, 61, 95–96, 101–114, pp 182–186, 208–209, 211–220
11. Ibid, fragment 61; *cf.* fragment 106, pp 183–186, 214–215; *Herophilus discovered the tubes but did not recognize their true course.*
12. *Cf.* Jackson R: Doctors and Diseases in the Roman Empire. Norman, Oklahoma/London, UK, University of Oklahoma Press, 1988, pp 112–129, *for an accessible survey; see* Galen: On Anatomical Procedures VII.13. In Claudii Galeni Opera Omnia, Vol. 2. Edited by CG Kühn. Leipzig, Germany, C Knobloch, 1821, pp 632–634, *for an operation involving excision of the sternum and exposure of the heart; the patient recovered.*
13. *See* Lloyd GER: Greek Science after Aristotle. London, UK, Chatto and Windus, 1973, p 77; Garland R: The Greek Way of Death. Ithaca, NY, Cornell University Press, 1985, p 28 (*on corpse-stealing*); *see also* [27]
14. *Most of the Greek sacred laws are conveniently assembled in the following collections:* Sokolowski F: Lois sacrées de l'Asie Mineure. Paris, France, Editions E de Boccard, 1955 (LSA); Sokolowski F: Lois sacrées des Cités grecques, Supplément. Paris, France, Editions E de Boccard, 1962 (LSS); Sokolowski F: Lois sacrées des Cités grecques. Paris, France, Editions E de Boccard, 1969 (LSCG); *I shall henceforth use the traditional abbreviations LSA, LSS, and LSCG to refer to these works.*
15. *See* LSCG 55, 57, 67, 97, 116, 124, 154, 156, 171; LSS 24, 53, 54, 91, 115, 119; LSA 12, 51; *cf.* von Staden H: Women and dirt, parts III–IV. Helios 19, 1992
16. Parker R: Miasma. Pollution and Purification in Early Greek Religion. Oxford, UK, Oxford University Press, 1983, p 32
17. *In Sophocles'* Antigone, *birds of prey have carried scraps of Polynices' unburied body to the altars of the gods, and the consequent pollution is so enormous that all efficacious exchange between humans and divinities has become impossible (*Antigone *lines 999–1047). In Euripides'* Hippolytus, *the goddess Artemis abandons her dying human favorite, Hippolytus, with the words: "Farewell! Sacred law forbids me from looking at the dead or staining my eye with the exhalation of death"* (lines 1437–1438). *Cf.* Barrett WS: Euripides. Hippolytos. Oxford, UK, 1964, p 414; *see also* Euripides: Alcestis line 22: *Apollo must leave the house in which Admetus is dying, "lest pollution* (miasma) *reach me in the house"*; Thucydides: 3.104.1–2; Callimachus: Hymn to Delos 275–277; Strabo: 9.5.5 (486C)
18. Callimachus: Hymn to Delos 206–211; [2] Herophilus: fragment 196, pp 367–368; *cf.* Most GW: Callimachus and Herophilus. Hermes 109: 188–196, 1981; [2], pp 394–395
19. Teles: On Exile, p 31.9–10. In Teletis Reliquiae, 2nd edition. Edited by O Hense. Tübingen, Germany, JCB Mohr, 1909
20. Suda, *s.v.* 'Philemon'. In Suidae Lexicon, Vol 4. Edited by A Adler. Leipzig, Germany, Teubner, 1935, p 722, *from* Aelian's On Providence
21. LSCG 97 (IG XII 5.593 or SIG^3 1218)
22. *For the funerary legislation attributed to Solon, see* Demosthenes: XXII, Against Macartatus, 62; *see* [16], pp 34–35, 40, *and, for the composite account that follows,* 34–41
23. *E.g.,* LSCG 55.6 (Attica: ten days of exclusion), 124.2–4 (Eresus: 20 days of exclusion for a relative, three for an acquaintance), 139.13 (Lindos: 40 days for a relative), 91.13–14 (Lindos: 41 days for a relative, seven for having washed a corpse, three for having entered the house in which the corpse lay); LSA 84.6–9 (Smyrna: ten days for a relative, three for an acquaintance)
24. LSCG 97B.1–11
25. LSCG 154.B.17–32
26. *A scholium on Sophocles,* Antigone *255, explains the sentence, "the corpse had become invisible, not covered with a mound but sprinkled with dust as by one escaping from [avoiding] pollution" (i.e., Antigone's act of sprinkling dust on Polynices' unburied corpse), as follows:* "The reason is that Bouzyges [a legendary Athenian hero] called down curses at Athens on those who neglect an unburied body"; *see also* Aelian: Varia Historia 5.14: "This is a law in Attica: whoever chances upon an unburied body of a human being absolutely must cover it with earth and bury it looking to the setting of the sun." Suda, *s.v. ektinōn,* II, p 233.16–17 Adler (from Aelian, fragment 242 Hercher): "Paying back one's obligation to Mother Earth, one buries a shipwrecked person"; idem, *s.v. akēdēs* (I, p 80.20–23 Adler; from Aelian, *ibid*): "When I saw the body of a shipwrecked person hurled up [on the beach] and uncared for, I did not dare to pass by but I buried the dead person, concealing a sight nowhere dear to the sun, in accordance with human law." *Cf.* Horace: Odes, I.28.33; Nisbet RGM, Hubbard M: A

Commentary on Horace: Odes, Book I. Oxford, UK, Oxford University Press, 1970, p 332, *with further evidence that "the ancient world had deep-rooted anxieties about the unburied corpse."*

27. *See* [16], pp 45–48; [13] above
28. *For examples of the numerous Greek sacred laws regulating the disposition of skins, see* LSCG 10A7–8, 14; 11B6, 14–18; 12A8–11; 18A22, 50–51; 18B38–39; 18E7–8; 28.5–6, 10–13, 20; 29.3–5; 45.6; 65.86; 69.28–30; 77D33–43; 90.6–7; 92.28–30; 117.5; 119.1–6; 120.3–4; 151A21, 49–50, 58–9, 63; 151B1, 7–8, 20–21; 154B39, 42–44; 156A27–28; 156B9–16; 163.14–16; 164.3–4; 166.63–65; *see also* LSA 12.12–14, 22–26; 13.13–15; 46.1, 6–8; *and* LSS 61.62–63,115B17. *On the complex valorizations of animal skin in sacrifice, and on the fact that the skin—whole—is all that remains behind of an animal after successful sacrifice, see* Vernant JP: À la table des hommes. In La cuisine du sacrifice en pays grec. Edited by M Detienne, JP Vernant. Paris, France, Gallimard, 1979, pp 92–93; Durand JL: Bêtes grecques. Ibid, pp 141–143, 156–157; Vernant JP: Manger au pays du Soleil. Ibid, p 244
29. *Suda,* E.2471 (II, p 370, lines 6–8 and 14–15 [20]); Diogenianus: Centuria VIII 28; Diogenes Laertius: I 115, from Sosibius; Jacoby F: Fragmente der griechischen Historiker, III B. Leiden, The Netherlands, EJ Brill, 1950, 457T1–2 *and* 5(b), *with commentary;* Svenbro J: Phrasikleia. Anthropologie de la lecture en Grèce ancienne. Paris, France, 1988, pp 151–160, *offers a richly suggestive reading of Epimenides' skin. If, however, one takes* apothetōn *in the account by the* Suda (*loc. cit.*) *to be the genitive of* apothetai, *i.e., the "precipitous place" by Mount Taygetus into which the Spartans (who are, after all, the keepers of the "skin of Epimenides") threw their misshapen children immediately after birth* (Plutarch: Life of Lycurgus 16), *the "skin of Epimenides" becomes a very different kind of repository.*
30. *See* Roscher WH: Ausführliches Lexikon der griechischen und römischen Mythologie, Vol 2. Leipzig, Germany, Teubner, 1890–1897, pp 1014ff
31. *In Libya, Dido persuaded Hiarbas to let her buy as much land as the hide of an ox could occupy. She then "extended" the hide and created a new, symbolic "skin," paradoxically by cutting it into a single long, thin strand—or into long strands—with which she occupied a space (for a new city) that had a circumference of 28 stades; this skin boundary again symbolized the integrity of the new foundation. The new city (Carthage), the ancients report, was hence called "Byrsa" (Greek* byrsa *means "skin," "hide," or "skin stripped off an animal"). See* Servius' commentary *on* Virgil's Aeneid I.367; Appian: Roman History VIII (Libya), 1.1–5. *But see also the role ascribed to Elissa by* Justin: Epitoma Historiarum Philippicarum Pompei Trogi, XVIII.5.8–11, *and by* Timaeus: 566F82 Jacoby. *Cf.* Scheid J, Svenbro J: La ruse d'Elissa et la fondation de Carthage. Annales. Économies Societés Civilisations 2:328–342, 1985
32. *This is true in Greek medical literature too: Hippocratic writers sometimes point to healthy skin as a sign of a well-ordered body and to unhealthy skin as a sign of disorder. This is, however, not a universally applicable principle in the Hippocratics. Thus an excellent complexion, if combined with a sullen look, can be a bad sign; cf., e.g.,* "Hippocrates," Coan Prognoses I.2.67 *and* II.8.210–11 (V, pp 598, 630 Littré)
33. [16], p 208: "There is reason to think that certain skin diseases, in particular, were popularly seen as pollutions that could be washed away."
34. Ps.-Aeschines: Epistle I.2
35. Aeschylus: Choephoroe 278–282; *on the Aeschylean notion of "savage disease," which recurs in Sophocles, Euripides, and the Hippocratic Corpus, see* Jouanna J: La maladie comme aggression. In La Maladie et les Maladies dans la Collection hippocratique. Edited by P Potter, G Maloney, J Desautels. Quebec, Canada, Editions Sphinx, 1990, pp 39–60
36. *See* Aretaeus: IV.13.8; Apollodorus: Library II.129–134 (=II.6.2–4); Diodorus of Sicily: IV.31.1–8; Sophocles: Trachiniae 980–981; the Aristotelian Problemata XXX.1.953a18–19; *on the "doubleness" and "reversibility" of Heracles' skin, see* von Staden H: The mind and skin of Heracles. In Maladie et Maladies. Mélanges en l'honneur de Mirko Grmek. Edited by D Gourevitch. Geneva, Switzerland, Librairie Droz, 1992, pp 131–150
37. *On Meleager and the boar hide see, for example,* Antoninus Liberalis: Metamorphoses II.3
38. *See* Fränkel H: Dichtung und Philosophie des frühen Griechentums. New York, American Philological Association, 1951, pp 183–186, 206–207, 403–404, 607, 638–639; Snell B: The Discovery of the Mind. New York, Harper and Row, 1960, pp 136–152; Wittern R: Grenzen der Heilkunst. Eine historische Betrachtung. Stuttgart, Germany, Robert Bosch Stiftung, 1982; von Staden H: Incurability and hopelessness: The Hippocratic Corpus. In [35], pp 75–112
39. *See* [16], chapter 4: The Shedding of Blood
40. *See, e.g.,* Iliad 3.103–105, 245–302; 19.169–269; Euripides: Suppliants 1196; *cf.* Rudhardt J: Notions fondamentales de la pensée religieuse et actes constitutifs du culte dans la Grece classique. Geneva,

Switzerland, E Droz, 1958, pp 282 ff; Burkert W: Greek Religion. Cambridge, MA, Harvard University Press, 1985, pp 55–68, 250–256

41. *This combination probably also gave rise to the Greek expression "to cut* (temnein) *an oath." On residues of the "ambiguity of the sacred" in Greek medicine, see* von Staden H: Women and dirt, part IV. Helios 19, 1992
42. *For divergent views on the etymology of* horkos, *see* Frisk H: Griechisches etymologisches Wörterbuch, Vol II. Heidelberg, Germany, C Winter, 1961 ff, pp 418–419, 388; Chantraine P: Dictionnaire étymologique de la langue grecque. Paris, France, Editions Klincksieck, 1968, p 821; Benveniste E: L'expression du serment dans la Grece ancienne. Revue d'histoire des religions 134:82–94, 1948; Bollack J: Styx et serments. Revue des études greques 71:1–35, 1958; Hiersche R: Note additionelle relative a l'étymologie d'*horkos* et d'*omnynai.* Revue des études grecques 71:35–41, 1958. *On the religious and civic importance of the oath in ancient Greece, see* Burkert W: Greek Religion. Cambridge, MA, Harvard University Press, 1985, pp 250–254; Hirzel R: Der Eid. Leipzig, Germany, Verlag S Hirzel, 1912
43. *On the oath as a form of verbal magic, see also* Brown NO: Hermes the Thief, chapters 1 and 5. Madison, WI, University of Wisconsin Press, 1947
44. *E.g.,* Iliad 9.209, 13.501, 16.761, 18.177; Odyssey 16.102; Hesiod: Works and Days 786, 791; Aeschylus: Choephoroe 1047, *and* Eumenides 592; Sophocles: Philoctetes 619; Euripides: Bacchae 241; Lucian: The Goddess of Syria 15 *(castration of a human)*
45. *For examples, see* [40] *and* [44]
46. *I do not wish to deny that* temnein *was used of surgical "cutting" as early as the* Iliad, *e.g., 11.844–5: Patroclus made Eurypylus* "lie stretched out there, and with his dagger cut [*tamne*] from Eurypylus' thigh the sharp, deeply piercing arrow." *Rather, as pointed out above, at issue are the early combination of* "dominant *use," crisis, and deep cutting, and the later* "systematic *secularization" of* temnein *for relatively superficial skin-cutting. See* "Hippocrates": Airs Waters Places 11 (II, p 52.1 Littré [*henceforth* Littré = L]); Prognostic 18 (II, p 164.1 L); Epidemics III.17, *eighth case history* (III, p 124.8 L); On Wounds in the Head 13 (III, p 230.12 L); On Joints 12 (IV, p 114.6–7 L); Aphorisms 5.68 (IV, p 560.5 L); On Diseases I.6 (VI, p 150.19–20 L); On Affections 4 (VI, p 212.15 L); On Places in Human Beings 13 (VI, p 300.24–5 L, *not a superficial incision*); On Diseases of Women I.2 (VIII, p 20.15 L, *iatrogenic cutting*)
47. *See, e.g.,* Lloyd GER: Magic, Reason and Experience. Cambridge, UK, Cambridge University Press, 1979, pp 240–267; Lloyd GER: The Revolutions of Wisdom. Studies in the Claims and Practice of Ancient Greek Science. Sather Classical Lectures 52, Berkeley/Los Angeles/London, University of California Press, 1987, pp 78–82; Lloyd GER: Demystifying Mentalities. Cambridge, UK, Cambridge University Press, 1990, pp 8–12, 58–67
48. *Perhaps the most striking case is that of Pericles' influential associate Anaxagoras of Clazomenae, who came to Athens about 480 B.C. and resided there for more than 40 years before being brought to trial on charges of impiety; he seems to have been exiled despite the fact that he was very close to the center of Athenian political power. Pericles' opponents might have been using Anaxagoras' trial as an indirect means of attacking the powerful Athenian statesman, but, according to the more authoritative ancient accounts, the indictment was based on the charge that Anaxagoras' boldly novel cosmological theories denied traditional, mythic views about the nature of the planets and of other celestial bodies. See* Plutarch: Life of Pericles 4–6, 8, 16, 32; Plutarch: Life of Nicias 23; Plutarch: Life of Lysander 12. *For rival versions of Anaxagoras' trial and fate—acquittal, fines, exile, imprisonment, execution, suicide, and various combinations thereof—see* Diogenes Laertius: Lives of the Philosophers II.12–15. *Another famous case is that of the Sophist Protagoras who, according to Diogenes Laertius (IX 52 and 54) and later sources, was exiled from Athens for his "agnostic" view on gods, and whose books were supposedly collected and burned in the agora; but the evidence in the case of Protagoras is less secure.*
49. *See especially* A Cornelius Celsus: Medicina 1 (Artes 6), prooemium 23–6
50. *For an excellent survey, see* Fraser PM: Ptolemaic Alexandria, 3 Vols. Oxford, UK, Oxford University Press, 1972, *especially* chapters 6–11
51. *The second Ptolemy ("Philadelphus," i.e., "Sister Lover") was the first monarch in the Greek world to practice intra-uterine incest (which had, however, long been practiced, in part for political reasons, by some—not all—Egyptian Pharaohs): he married his own sister, Arsinoe II, about 276 B.C. and had children by her. The Greek poet Sotades objected* inter alia *with his notoriously blunt verse:* "You're thrusting your prick [*kentron*] into an unholy hole"; Sotades, fr. 1, *in* Powell JU: Collectanea Alexandrina. Oxford, UK, The Clarendon Press, 1925, p 238. *The Stoic (or perhaps Cynic) views on the "moral indifference" of incest may also have played a role. See* von Arnim H: Stoicorum Veterum Fragmenta, 4 Vols. Leipzig,

Germany, Teubner, 1903–1924; reprinted Stuttgart, Germany, 1964, I, Zeno, fragment 256; III, Chrysippus, fragments 743–6

52. *See especially* Aristotle: On the Soul, Books II–III. *Cf. also* Aristotle: On Parts of Animals I.1.641a17–642a1; Aristotle: On Generation of Animals II.3.736a22–737b7 *and* II.4–5.740b24–741b24
53. *See* [50], Vol I, pp 314–316, 320–321, 427, 445, 453–454, 478, 483–484, 718–719, 770, 783
54. Aristotle: Meteorologica IV.12.389b31; *the subsequent part of this passage closely resembles the one to which* [55] *refers. (The view of some scholars that the fourth book of Aristotle's* Meteorologica *is inauthentic not only rests on questionable criteria but also is not of decisive significance here, in view of the parallel passage in* On Parts of Animals I.1.640b34ff.)
55. Aristotle: On Parts of Animals I.1.640b34–641a7, *in polemics against a view attributed to Democritus, viz. that each living creature and each of its parts is what it is by virtue of its shape and color*
56. Aristotle: Meteorologica IV.12.389b31–390a1
57. *See* von Arnim H: [51], Vol I, Zeno, fragments 134–151 *and* 196; Vol III, Chrysippus, fragments 773–911, *especially* 809–822; *see also* Long AA, Sedley DN: The Hellenistic Philosophers. Cambridge, UK, Cambridge University Press, 1987, Vol I, pp 69–72, 149–154, 272, 313–323, 418, *and* Vol II, pp 71–74, 154–159, 270 (45D), 310–321, 416 (65U)
58. *See* [2] pp 90–98
59. Von Arnim H: [51], Vol I, Zeno, fragment 190; Vol III, Chrysippus, fragments 117, 120, 256, *and* Diogenes of Babylon, fragment 39; *see also* Long AA, Sedley DN: [57], Vol I, pp 354–359, *and* Vol II, pp 349–355
60. Von Arnim H: [51], Vol I, Zeno, fragments 253–254; Vol III, Chrysipus, fragments 746–753
61. *The differences between religious mummification and systematic scientific dissection are considerable, as recognized by most ancient and modern scholars. The Egyptian embalmers, for example, scraped and drained out the brain piecemeal through the nostrils of the corpse, whereas Herophilus dissected the brain and the head meticulously enough to distinguish the ventricles of the brain, to discover and describe seven pairs of cranial nerves (optic, oculomotor, trigeminal, motor root of the trigeminal, facial, auditory, and hypoglossal nerves), to describe and name the* calamus scriptorius *(a cavity in the floor of the fourth ventricle of the brain), to discover and name the* torcular Herophili *(the confluence of the four great cranial venous sinuses) and the styloid process, and to distinguish the cornea, iris, retina, and choroid coat of the eye. These extraordinary discoveries are a far cry from what is learnt through ancient embalming practices. On mummification, see* Herodotus II.86; Diodorus of Sicily I.91; Mummies, Disease, and Ancient Cultures. Edited by A Cockburn, E Cockburn. Cambridge, UK, Cambridge University Press, 1980; Mokhtar G, Riad H, Iskander Z: Mummification in Ancient Egypt. Cairo, Egypt, Ministry of Culture, Egyptian Antiquities Organization, Cairo Museum, 1973. *For the evidence concerning Herophilus' dissections of the brain and the head, see* von Staden H: [2], pp 195–208 (fragments 75–94), 223–225 (fragments 121–125); *for a summary, see* ibid, pp 155–161
62. *The dissection of animals experienced a remarkable revival in the first and second centuries* A.D. *—a revival richly documented by Galen in his* On Anatomical Procedures*—but* systematic *human dissection was, it seems, never resumed in antiquity.*
63. *In* [2], pp 150–151, *I was perhaps unduly optimistic about the possibility of causally linking these later developments to the cessation of systematic human dissection.*
64. *See* [19], [25], [26], [27]
65. *See* [51], *on the poet Sotades' criticism of a Ptolemy*
66. *See* Deichgraber K: Die griechische Empirikerschule, 2nd edition. Berlin, Germany/Zurich, Switzerland, Weidmannsche Verlagsbuchhandlung, 1965, pp 130–132, 281–288; Walzer R, Frede M: Galen. Three Treatises on the Nature of Science. Indianapolis, IN, Hackett, 1985, pp xx–xxxi, 3–4, 7–13, 23–37, 41–45, 67ff
67. Ibid, fragments 14 (*especially* p 93.33ff.), 24 (*especially* p 105.23–9), 66–70
68. *See* von Staden H: [8]:188–193
69. Celsus: Artes 6 (Medicina I), prooem. 23–26
70. Ibid, 40–43
71. *See* Kudlien F: Hippokrates-Rezeption im Hellenismus. In Die Hippokratischen Epidemien. Edited by G Baader, R Winau. Sudhoffs Archiv, Beiheft 27, 1989, pp 355–376; von Staden H: [2], pp 70–72, 74–76, 81–83, 299–301, 427–442, 452–458, 485–503, 555–556, 560–561
72. Plutarch: Life of Alexander 26; *see* [4] *for other ancient versions of these events: Arrian, Strabo, and Ammianus Marcellinus omit the story of the birds while retaining versions of the flour as a favorable omen.*